USN

06EE55

Fifth Semester B.E. Degree Examination, June/July 2017
Modern Control Theory

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Define state, state variable and state space. Form the state model for a single input single output continuous LTI system. **(08 Marks)**

b. Construct the state diagram and state model for the following differential equation:

$$\frac{d^3y}{dt^3}+6\frac{d^2y}{dt^2}+11\frac{dy}{dt}+6y(t)=10u(t).$$ **(08 Marks)**

c. Mention any four advantages of state variable method over conventional control system. **(04 Marks)**

2 a. Obtain the state model for the armature controlled d.c. motor. **(08 Marks)**

b. A feed back system is represented by the closed roof transfer function:

$T(s)=\dfrac{s^2+3s+3}{s^3+2s^2+3s+1}$. Draw a suitable signal flow graph and obtain the state model. **(06 Marks)**

c. Obtain the state model in Jordan's canonical form of a system whose transfer function is $T(s)=\dfrac{1}{(s+2)^2(s+1)}$. **(06 Marks)**

3 a. Obtain the transfer for the state model

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-2 & -3\\ 4 & 2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}3\\ 5\end{bmatrix}U \quad \text{and} \quad y=\begin{bmatrix}1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}.$$ **(06 Marks)**

b. Consider a state model with matrix 'A' as

$$A=\begin{bmatrix}0 & 2 & 0\\ 4 & 0 & 1\\ -48 & -34 & -9\end{bmatrix}.$$

Obtain the modal matrix 'M' and also prove that the transformation M^{-1} AM results in a diagonal matrix. **(08 Marks)**

c. Mention any three properties of properties of Eigen values and prove the invariance of Eigen values. **(06 Marks)**

4 a. Mention any four properties of State Transition Matrix (STM). **(04 Marks)**

b. Obtain the complete time response of the system given by

$$\dot{X}(t)=\begin{bmatrix}0 & 1\\ -2 & 0\end{bmatrix}\times(t) \quad \text{and} \quad y(t)=[1, -1]\,X(t) \quad \text{where } x(0)=\begin{bmatrix}1\\ 1\end{bmatrix}.$$ **(10 Marks)**

c. Find $f(A)=A^{12}$ for $A=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}$ using Cayley-Hamilton theorem. **(06 Marks)**

PART – B

5 a. A regulator system has the plant

$$\dot{x} = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} 0 \quad \text{and} \quad y = [0\ 0\ 1]x.$$

Obtain the state feedback matrix by direct substitution method. Given the desired poles (closed loop) to be at $-2 + j\sqrt{12}$, $-2 - j\sqrt{12}$ and -5. **(08 Marks)**

b. Consider the regulator system given by $\dot{x} = Ax + Bu$ where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}.$$

The system uses the state feedback control u = -kx. Determine the state feedback gain matrix K using Akerman and formula if the poles are heated at -2 + j4; -2-j4; -10. **(08 Marks)**

c. With a neat diagram, explain P-I controller. **(04 Marks)**

6 a. Explain briefly the characteristic features of non-linear system. **(04 Marks)**

b. Give the satisfaction of non-linear systems with suitable examples. **(04 Marks)**

c. Explain the following non-linearities:

i) Saturation
ii) Dead zone
iii) On-Off non-linearity
iv) Back-Lash in gears. **(12 Marks)**

7 a. Explain the following with respect to non-linear systems:
i) Limit cycles; ii) Jump resonance. **(06 Marks)**

b. Find out the singular points for the following systems:

i) $\ddot{x} + 0.5\dot{x} + 2x = 0$
ii) $\ddot{y} + 3\dot{y} + 2y = 0$ and
iii) $\ddot{y} + 3\dot{y} - 10 = 0$. **(06 Marks)**

c. Construct a phase trajectory by delta method for a non-linear system represented by the differential equation $\ddot{x} + 4|\dot{x}|\dot{x} + 4x = 0$. Choose initial conditions as $x_1(0)$ = 1.0and $\dot{x}(0) = 0$. **(08 Marks)**

8 a. Define the following: i) Positive definiteness; ii) Negative definiteness.
and also give the sufficient condition for stability. **(06 Marks)**

b. Use Krasovoski and theorem to show that the equilibrium state x = 0 of the system described by: $\dot{x}_1 = -3x_1 + x_2$; ii) $\dot{x}_2 = x_1 - x_2 - x_2^3$ is asymptotically stable in the large. **(08 Marks)**

c. Determine whether or not the following quadratic form is positive definite:
$V(x) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$. **(06 Marks)**

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